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ABSTRACT

Research designed to understand the underachievement of minorities in general, and Latino immigrants in particular, is summarized as it relates to mathematics. Two paradigms have dominated this research: the Deficit paradigm and the Cultural Difference paradigm. A third paradigm, the Holistic paradigm, seems to account for most of the deficiencies of the other two models. The first section of the paper presents the advantages and disadvantages of the Deficit and Cultural Difference paradigms, and the second section presents the Holistic paradigm, which considers various relevant aspects, including societal influences, teacher attitudes, school mathematics curricula, student attitudes and behavior, and classroom processes. The final section reviews recent studies that have addressed the problem of minority underachievement in mathematics. The Contextual Systems Model proposed by R. Pianta and D. Walsh (1996) provides a framework for this exploration. (Contains 2 figures and 45 references.) (SLD)

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A Review of Literature on Under Achievement of Minorities in Mathematics

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Abstract

This paper was written to provide a context for the discussions carried out by the participants in the Symposium: Intersections: Mathematics, Culture, and Language, *presented during the Annual Meeting of the American Educational Research Association, San Diego, CA, April 13-17, 1998. It presents the general problem of under achievement of minorities in the US, followed by a brief account of the different approaches that have been used in research to understand the problem. The paper ends with a review of recent literature that works under a holistic paradigm—mostly with Latino populations, (Pianta & Walsh, 1996) with a recommendation for new orientations for research in this area.*

The Problem

Skovsmose (1990) and the NCTM Standards (1989) have emphasized that mathematics literacy of the citizens is a necessity for maintaining the informatized society.[1] The consideration of what should be done in order to accomplish the goal that all the citizens acquire mathematical literacy that ensures their successful participation in this new society is a problem that has been explored from different perspectives. In this context, students' mathematical under achievement has become an indicator that the goal has not yet been met. The changes that the US faces in ethnic composition due to immigration[2] adds another component to the problem of attaining a high level of mathematical literacy, principally because researchers have found that under achievement is more frequently observed in minorities (Secada, 1992, contains a state-of-the-art report on the research conducted up to 1991). The continuing increase in the number of immigrant children and youth in American schools and colleges has raised the two questions of how they affect these educational institutions and how they perform in them. These youths will

[1] The term is used to make a contrast with the industrialized society, in which the operation of machines does not require a highly prepared worker. The increasing reliance on computerized processes requires a high level of decision-making ability from operators (Skovsmose, 1990).

[2] According to Vernez and Abrahamse (1996), the proportion of immigrants has doubled in 10 years (from 233,000 in 1980 to 597,238 in 1990). California has received almost the half of them (250,143 in 1990) (p. 17). On the other hand, according to the 1990 Census, Georgia received 92,080 immigrants from abroad in 1990 (Census 1990, on-line).

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eventually enter a national economy that is changing towards a highly informatized one, and the demands on better educated workers are also growing.

The continual reports of under achievement, dropouts, and failure to drop-in of immigrants (and in general of minorities) (Graham, 1987; Mathews et al., 1984; Ogbu, 1983; Smith, 1997; Valverde, 1984) and the impact that under achievement has on the nation's growth (Bianchi, 1997; Young, 1997) have made it possible for more funds to be available for research and development programs designed to understand and provide a solution to the phenomenon of under achievement of these groups.

Approaches to the problem of minorities' under achievement include the development of models that outline the factors that have more or less influence on it (Brenner, 1992; Cole & Bruner, 1971; Pianta and Walsh, 1996; Stanic & Reyes, 1988), the formulation of policies to support equal opportunity for minorities (Bianchi, 1997), and the implementation of school and teacher-parent development programs in which multiculturalism and new teaching practices and parental support are central (Brenner, 1992; Civil, 1996; Secada, 1995; Warren & Roseberry, 1995).

The purpose of this paper is to summarize of the research designed to understand the phenomenon of under achievement of minorities in general, and of Latino immigrants in particular, with reference to mathematics. I wanted to focus the presentation on research conducted in the 1990s; nevertheless, a brief account of what was done before 1990 is needed for understanding the trends observed in this decade. Two paradigms have dominated the research: the Deficit paradigm and the Cultural Difference paradigm. A third, the Holistic paradigm, has been proposed, and despite the difficulties involved in its application, it seems to account for most of the deficiencies of the other two models.

I have divided the paper into three sections. In the first I present an account of the advantages and disadvantages of the Deficit and Cultural-Difference paradigms; the next presents the Holistic paradigm; and the last presents a brief account of what has been done in research in under achievement in mathematics using a Holistic approach.

THE *DEFICIT* AND *CULTURAL DIFFERENCE* PARADIGMS

Pianta and Walsh (1996) used the triangle–which they call invidious–Child-Family-School to show that the Deficit and Cultural Difference paradigms have localized the problem at one vertex of the triangle and thus have been insufficient to explain the complexity of the phenomenon of under achievement among minorities.[3] The Deficit paradigm assumes that the child comes to school with a deficit, whether biological, genetic, or cultural (because his or her home is culturally deprived) that puts the child in a disadvantaged situation with respect to the other more capable students, usually those belonging to the dominant class.

Pianta and Walsh (1990) mention two positive consequences of this paradigm. On the one hand, it has allowed the flourishing of special education programs, with their body of research and practices, that provide procedures for detecting of children's difficulties, together with special programs for helping them to cope with those difficulties. On the other hand, if the problem is defined as a deficiency in the home, a solution has been to give the disadvantaged children in schools what they were deprived of at home, and also to improve their situation at home. These were the main achievements of the Head Start Programs, which not only provided learning environments for poorer children, but also involved their parents and offered health care services. The problem of the deficit paradigm as a model for explaining minorities' under achievement is that it does not acknowledge the richness and complexity of children's own cultures; it presents an "inaccurate and invidious view of non-dominant groups and their cultures" (Pianta & Walsh, p. 42).[4]

In 1971, Cole and Bruner wrote a paper claiming that the cultural deficit theory was giving wrong answers to questions about the intellectual performance of minority (in fact, poor) groups. The authors cited Labov's (1970) attack on three points in which the deficit paradigm was grounded: the assumption that all groups had to have the same functionality in language; the assumption that the researcher had the ability to interpret the data the subjects were giving, and

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[3]The argument is made for studying the problem of children at risk. Nevertheless the analysis is worthwhile as a guide for the broader analysis discussed here given the scope of the criticism.
[4]The authors mention also that even though the words *disadvantaged* and *deprived* are not publicly used, "they remain alive and well in contemporary school hallways and elsewhere" (p. 42).

the idea that when the subjects participated in different testing situations the results were the same. Labov showed that all the three points were not true in reality and concluded that researchers' definitions of culture were incomplete. In Lavob's view, what was treated as a *deficit* should be considered as a *difference*. Using Labov's findings as argument, Cole and Bruner suggested, along the same line, that teachers needed to see the students as culturally different, not as having an intellectual disease, and in consequence, that they should understand that their task as teachers was not to teach the students certain skills but to provide an environment in which the children would show that they already possessed those skills and then help them to transfer the skills to new situations.

This was the birth of the Cultural Difference paradigm, which, according to Pianta and Walsh (1990), corresponded to a shift of belief about the source of the problem, from the student and their homes to the school (and in consequence to the teachers). Under this paradigm, the child was not seen anymore as "broken," but as different. Children from non dominant cultures were perceived as unable to perform at levels similar to their peers of the dominant culture, because for the culturally different student, the school is completely unfamiliar. One consequence of this view for research was the growing recognition of researcher bias in previously well-known research (see Gould, 1981) and a dawning awareness of the need to improve the quality of experimentation methods (Cole et al., 1971; Labov, 1970). An implication that the Cultural Difference paradigm had for practice was that schools, and teachers, were asked to be more culturally responsive to children.

Although this paradigm represented an improvement over the deficit paradigm because it did not "blame the victim," it was limited because it assumed a simplistic and static conception of culture. Culture was seen as a system of rules and structures that are often hidden to the outsider but are well known by the insider. This is not true in general (see Gay & Cole, 1967) and does not apply to the rapidly changing cultures that make up the United States. This view also neglects the fact that even though each cultural group expects that their children will become functional adults, the reality is that some children in each culture transform themselves into dysfunctional adults in spite of the group leaders' efforts. This paradigm does not recognize that

competence is not easily moved from one situation to the next and that this is a problem not only of minority groups of the learning process in general. Finally, the biggest disadvantage is that this paradigm speaks only of one source of the problem, the school, and does not address other possible sources.

An important consequence of these two earlier approaches is that they have shown that a theoretical framework is needed; one that helps give an account not only of the multiple elements that intervene in the phenomenon of under achievement in general and of minorities in particular, but also of the relationships between them. The need to account for the complexity has contributed to the expansion of our view of what research is and has made evident our responsibility in providing explanations that give, besides understanding, solutions and effective ways to cope with the general purpose of having a mathematically proficient citizenry.

THE HOLISTIC PARADIGM

Many researchers looking for an explanatory model for under achievement of minorities have identified a wide range of factors as relevant: students' home background, motivation, and performance; parents' expectations, educational level and socio-economic status (SES); school curriculum, number of courses the students take, teacher-student interaction, and school organization. The predominant methodology used is quantitative (analysis of variance or correlation) in which one of the factors listed above is taken as the "treatment," and differences between ethnic groups[5] are explained in terms of variation of (or correlation with) the other factors (see, e.g., Alatorre-Alva, 1991; Chubb & Moe, 1990; Duran & Weffer, 1992; Moore & Smith, 1985). According to Pianta and Walsh, this approach is reductionist because many of the correlations and differences might be explained by factors that are not considered in the list (e.g., neighborhood, peer interaction,[6] and commitment of the participants). This lack of acknowledgment of other possible factors that are related to under achievement of minorities led, in some cases, to biased samples (Chubb & Moe, 1990, p. 111) and to an oversimplification of

[5] The ethnic groups most frequently compared are White, African-American, Hispanic, and Asian.
[6] Strutchens (1996) presents a case study in which the impact of peer interaction on the desire to learn of five African-American sixth graders is highlighted.

the relationships between them. And even though we know that no model will be able to account for all the relationships, a useful model is one that allows the researcher to show where and how a specific factor or relationship would fit.,

"Complexity should not be an excuse not to reform school but rather a cue to apply and develop conceptual frameworks that can give rise to reform actions that recognize contemporary reality" (Pianta & Walsh, p. 53). This is the stepping stone for the so called Holistic paradigm. One proposed model with this view is Reyes and Stanic's (1988) model to explain differences in mathematics achievement based on the race, sex, and socioeconomic status of students (p. 30). In this model, five aspects were considered to be relevant: societal influences, teacher attitudes, school mathematics curricula, student attitudes and achievement-related behavior, and classroom processes. Reyes and Stanic mentioned that some correlations between the factors were supported by research and, in consequence, that the next step needed was to determine the causal relationships between them. They made a explicit call for future works to "consider the [causal] interaction of race, sex, and socioeconomic status" on under achievement (p. 40). The interest of the model resides in the fact that the elements considered under each aspect gave a comprehensive account of all the possible sources of the problem (see Table 1) although a factor usually considered relevant, the school environment (or organization), is missing.[7]

Table 1: Aspects and Elements Studied in Reyes & Stanic's Model to Explain Differences in Mathematics Achievement Based on the Race, Sex and Socioeconomic Status of Students.

Aspects	Elements
Societal influences	Family, neighborhood, religious institutions, mass media, implicit messages that result from the patterns of prevailing occupational and other societal roles held by particular members of the group
Teacher attitudes (and practices)	Views and practices about the aptitudes of the students and about the appropriateness of their achieving at a high level in mathematics.[a]
School mathematics curricula	Courses available to students, topics covered by the courses, activities used to teach those topics.

[7]Chubb and Moe's (1990) model defines the impact of school organization using economic resources (money spent by the school/by district per pupil, teacher's salary, student-teacher ratio, and other facilities, like laboratories) and size. Perry, Valero and Gómez (1996) provides a summary of the underlying assumptions and results of ten joint projects conducted with administrative staff and mathematics teachers that have helped to improve the overall attitude of teachers and students towards mathematics in ten public schools in Bogotá, Colombia.

Student attitudes and achievement-related behavior	Attitudes: Confidence in learning mathematics, beliefs about the appropriateness of mathematics as an area of study, attributions of success and failure in mathematics, and attitudes toward other students and toward teachers. Behavior: persistence, independence, and deciding to enroll in optional mathematics courses.
Classroom processes	Interaction between teachers and students and between fellow students.

[a]. A caveat is made here, since the authors mention that a model for teacher attitudes is needed and that the definition of *attitude* is also crucial.

Pianta and Walsh (1996) proposed the Contextual Systems Model (CSM) as an improvement over the earlier models. The model attempts to explain development in the schools and is not related to any subject in particular. It accounts for "relationships between child and family, and schooling and the other individuals and institutions involved in schooling." (p. 54) The model is based on Ford and Lerner's (1992) Developmental System Theory (DST), whose application is in biology.[8] DTS's basic assumption is that "both stability and change in all facets of humans result from mutual causal processes among multiple variables, that somewhat different combination of variables may lead to the same developmental outcome, and that development does not result solely from simpler linear, additive processes but also from combinations of stability maintaining states altered or interrupted by periods of incremental and transformational change" (p. 208).

The CSM involves two interrelated systems, the Child/Family system and the School/Schooling system (see Figure 1). Both systems are interrelated, and time acts as an underlying relation affecting both. The utility of this model for understanding "at-risk" children is that it provides a wider and long-term view of risk, one rooted in children's social and emotional processes, involving the context around them, and with school and schooling affecting and shaping, in a consensual mode, children's development process. Pianta and Walsh (1996) argue that hazards (poverty, social insularity, unemployment, household organization and stimulation, neighborhood hazards, marital relationships and single parenting, child

[8] The ideas were developed using Bertalanffy's (1968) General Systems Theory and incorporated Vygotskian perspectives.

maltreatment, parental psychiatric distress, and peer rejection) are organized as a system that exert a regulatory influence on children's development and that "many of the problems children present in school, from lack of readiness to behavioral problems, are not all located in their heads, their families, or their schools. Instead, children's 'pathologies' are the extension of a complex, developmental process that has its roots in systems ranging from cultures to social interaction" (p. 136). The CSM advocates changes that would yield increased knowledge about the lives of children who come to school (better communication between the two systems, child/family and school/schooling), and the creation "of open, flexible, integrated whole systems that wrap children and sustain them" (p. 172) (understanding the sources of the conditions, instead of ignoring them or pretending to change them).

INSERT FIGURE 1 HERE

Pianta and Walsh's work is important for several reasons. The model is comprehensive; it shows the different actors involved in the process of a child's learning, and shows how they relate to and affect each other.[9] The model applies not only to children at risk. Probably this is the most important shift that we as researcher need to have in mind when studying minorities, commonly labeled at risk. It is a problem of education in general, and not a problem of a particular disadvantaged, different group. The model helps us understand why reform movements in mathematics have or have not succeeded; by taking a look at how reform has affected the relationships between the actors, it will be possible to produce a description of how the reform has been understood and applied. Thinking in a more prescriptive way, the model presents a new way for understanding how it is more likely that change will take place.[10]

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[9] In this respect, the model resembles an ecological approach.

[10] Cotton and Gates (1996) have argued for the need of incorporating to the psychological endeavor the social and political components of the teaching of mathematics. Gates (1997) went further when he claimed that ideology might serve a framework that "will be able to predict how individuals may act/think. Seen as a framework, ideology considers the nature of ideas, where these derive, how are they mediated, how belief and activity are related, and

RECENT WORKS

In this last section I will follow Pianta and Walsh's model to characterize recent studies that have addressed the problem of under achievement of minorities in mathematics from different perspectives. Teacher education, motivation to learn, parental involvement, and classroom discourse are some of the themes of the studies presented here.

A systemic approach has been used by Khisty (1997) in a project for in-service mathematics teachers whose purpose was to help the teachers to acquire a holistic view of their teaching activity with Latino students. Preliminary results on the teachers' change show that the teachers have difficulties in understanding concepts and skills of their own teaching repertoire and in making connections between processes and concepts in mathematics, between assessment and instruction, and between mathematics and other subjects. The fact that most training programs are short-termed and also fragmented hinders the possibility of acquiring a connected and holistic view of the teaching process. Khisty suggests that a systemic approach promotes the holistic, or systemic, thinking and that the complexity that systems have require to put rational boundaries: systemic thinking comprises "globally thinking but acting locally" (p. 133). She also points out the role of communicative actions as one that allows the actors to construct meanings; in the case of teachers, the process allows them to "build up pedagogical and mathematical concepts and to instill a mode to look at relationships" (p. 134). I found it worthwhile to include this work here because the researcher used a systemic approach as means and as objective. Nevertheless, Khisty's work is an example of changes produced on one of the elements of the system, the teacher in the School/Schooling system, by using the idea of system as a guiding principle. Questions remain as to what extent these changes influence the whole entity, and in particular how these changes affect students' learning of mathematics.

The relation between parents and schools, known as "parental involvement" has been addressed in several studies. Some works focus on this relation from a sociological perspective

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how common sense is constructed, interpreted and justified" (p. 309). I think that the bottom line here is the same, finding a holistic approach to the problem. The use of the concept of "ideology" might still be serving only a political purpose that can be pervasive to the idea of understanding the phenomenon from a scholarly standpoint.

(see e.g., Coleman, 1994; Epstein, 1994, and Smith, 1996). Epstein suggests that "the term 'school, family, and community partnerships' is a better, broader term than 'parent involvement' to express interests, responsibilities, investments, and the overlapping influences of family, school and community for the education and development of the children" (p. 39). She continues explaining how this new definition allows other elements that surround children to be incorporated to understand the process of parental involvement in schools and how it supports children in schools. Her framework provides a useful tool for studying the relations between the two external circles of the Child/Family System and the external circle of the School System in the CSM. But, as with other works in sociology, the subject taught is not questioned.

Studies addressing parental involvement and teaching and learning of mathematics have been done principally at the elementary levels, and their main purpose has been to offer teachers and parents alternative ways of communicating about children's progress and about parents and teachers' perspectives and expectations (Myers, 1996; Tamayo, 1992). The focus of these studies is on the affective component of mathematics learning. Hart and Allexsaht-Snider (1997) have done a literature review regarding motivational aspects in relation to mathematical achievement of minorities, under the assumption that motivation for mathematics learning is intrinsically related to the socio-cultural context in which students and teachers are immersed. This work raises interesting research questions in which success, belongingness, resistance, curriculum, and instruction are proposed as socio-cultural phenomena that have different definitions according to the particular school setting and socioeconomical contexts outside of school. The proposed questions look at the relations between the external circles of the Family/Child system and the whole School system.

Of particular interest is Civil's work (1996) with elementary school, working class, language minority children, in which the idea of "funds of knowledge"[11] is used to develop teaching innovations that capitalize on the "wealth of knowledge and resourcefulness of children" (p. 3). The children come from families who have "extensive knowledge about

[11] *Funds of knowledge* are defined as "the essential bodies of knowledge and information that households use to survive, to get ahead, or to thrive." (quoted from Moll, Vélez-Ibáñez, Greenberg, et al., 1990, p. 2, by Civil, p. 2).

construction, repairs, carpentry, household management, folk medicine, farming" (p. 3) and participate in many of these activities, often learning about them through an apprenticeship model. By using an action-research methodology, the teachers went to the children's houses to learn and uncover their funds of knowledge. During study group discussions, the teachers and researchers organized the information and worked out ideas that were transformed into classroom activities, that afterward were implemented and assessed in the mathematics classroom.

Civil's work is important because it raises some issues rarely problematized: To what extent is the mathematics that is being taught preparing the student for the more formal and abstract aspects of mathematics that they are expected to tackle later in their schooling? How are the students going to be able to differentiate the new from the old in their learning? And more important, do they view the mathematics embedded in the modules as "real" mathematics? "Students may have indeed been involved in rich mathematical opportunities but if they do not see what they did as 'school mathematics,' or if the connections to what they may expect to see in the next grade are not made, are we helping these children?" (p. 6). These are issues that are crucial to the phenomenon of teaching and learning of mathematics and that, as I said before, have not been studied from a sociological perspective.

Khisty (1995), as a consequence of her analysis of the discourse in a bilingual mathematics classroom, observed that Spanish was used to foster lexical, not mathematical, acquisition. This led her to claim that mathematics teaching and learning should transcend linguistic considerations; that is, that the phenomenon of teaching and learning mathematics is not solely related to particular conditions of the participants in any classroom. In consequence, the idea of having a different paradigm to study particular groups of students is inappropriate: The paradigm should help us understand the phenomenon in itself, as a whole.

One study that addresses the issue of parental involvement in relation to mathematics at the secondary level is Peressini's doctoral dissertation (1996). In this work, Peressini uses the concept of power relationship between parents and teachers as a way of explaining how the relation between the two systems, Family/Child and School, expresses itself when a movement for reform is at stake. The work is valuable because of the historic account of how different -

changes affecting the mathematics curriculum in the US have implicitly and explicitly precluded parental involvement in mathematics–arguing basically that parents lack content knowledge (pp. 25-30)– and how this explains in some cases the failure of reform movements that are intended to benefit minorities. This work can be seen as an attempt to understand the interrelation between the second circle of the Family/ Child system and the School system, in a general sense. The continual references to mathematics reform are the only tie to mathematics offered by this work.

Attending only to classroom activity, Stodolsky (1988), in her study of 39 fifth grade classrooms in 13 schools in different districts in the metropolitan area of Chicago, found that instruction was not the same for social sciences and mathematics. Individual teachers arranged instruction differently depending on what they were teaching. Thus, it would be interesting to see how a sociological approach could be used to understand the connections between what happens outside the school and the activities inside the mathematics classroom.[12]

One work that can be characterized as attending to the inner circles of the School system is Moschkovich's (1996) analysis of how Latino students construct mathematical meaning in a bilingual classroom. She offers a situated framework[13] as a way to understand students' learning and doing of mathematics: "Within this model, language use and its relationships to math learning depend on the situation" (p. 30). The situation considers such aspects as type of problem (computational or conceptual), sub-field (algebra, geometry), representational resources available (manipulatives, symbols, graphs), historical context (students' language and mathematical acquisition) and social context (interlocutor and membership). She shows that a situated perspective offers a better understanding of the process of construction of meanings in both a Geometry and an Algebra class than a discontinuity model that reduces the use of meanings to a manipulation of technical terms, and that may assume that the students' everyday context is an obstacle instead of a resource for learning mathematics. I see this work as an expression of a holistic paradigm at a microlevel of analysis.

[12] I want to make clear that I do not want to use the argument that "everything is related to everything," because such a simplistic answer does not help me to understand the nature of the relationships, which I think is what is at stake. Chavkin (1996) offers an interesting alternative through a partnership program that shows improvement in students' mathematics achievement in a public school.

[13] The framework is constructed upon what is known as situated cognition (Lave, 1991).

CONCLUSIONS

The research on under achievement of minorities reviewed in this paper considered three paradigms: Cultural Deficit, Cultural Difference, and Holistic. The first two were considered as inappropriate because of their limited views of culture and because they put the responsibility of the learning and teaching process on the people involved rather than on the interactions between people and institutions acting in the process. I have organized the recent research on under achievement of minorities using a Context System Model (Pianta & Walsh, 1996), which looks for accounting for the relationship between the Family/Child system and the School system (see Figure 2).

Figure 2: Organization of recent works according to the CSM

INSERT FIGURE 2 HERE

The works have expressed the need to use a holistic approach, even though they have concentrated on particular aspects of the system. Each work has illuminated essential and particular characteristics of each of the relationships treated. Nevertheless, I consider that what is missing is a theoretical treatment of the evolution of the mathematical discourse, whether in the classroom, in textbooks, in teacher education programs (in-service or preservice), or in parent-teacher meetings, and its relation to the social, cultural, and political aspects that define a particular setting. As Sfard (1997) suggests, we can see learning as the participation of students in the construction of the discourse about the mathematical objects. We do not want to explore what is inside the student's head–the psychological avenue–but rather to make explicit students', teachers' and other actors' participation in the creation of mathematical discourse. The secondary levels also need to be addressed, and I think that our knowledge would benefit from a more balanced–qualitative and quantitative–use of methods of inquiry.

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The Contextual Systems Model (CSM)

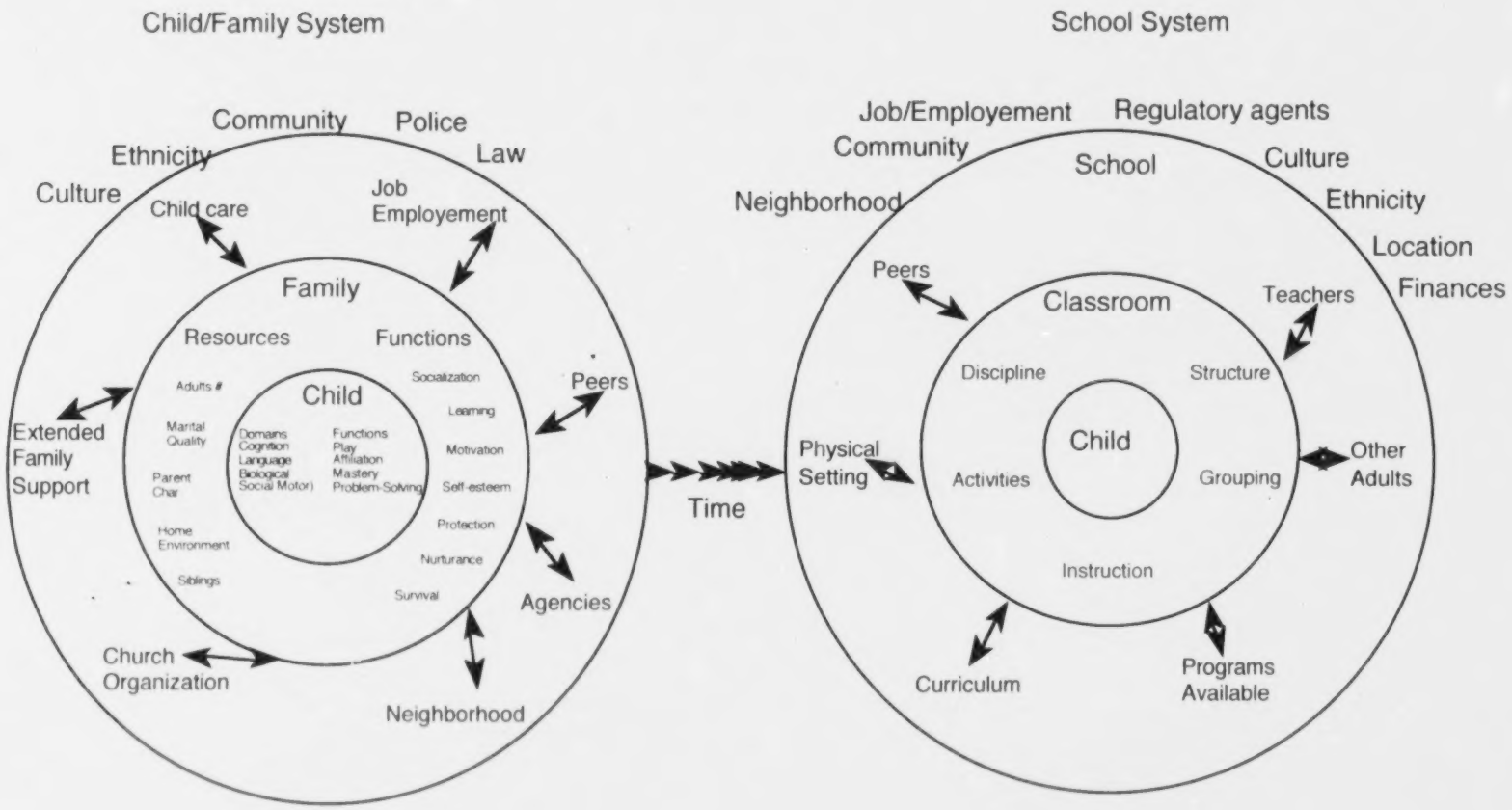

FIGURE 2
CAPTION:
Figure 2: Organization of recent works according to the CSM